# 1. Phloem Loading and Unloading in Plants

# 2. Source–sink relationship

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**1.** Translocation of organic solutes such as sucrose (i.e. photosynthetic) takes place through sieve tube elements of phloem from supply end (or source) to consumption end (or sink). But, before this translocation of sugars could proceed, the soluble sugars must be transferred from mesophyll cells to sieve tube elements of the respective leaves.

This transfer of sugars (photosynthetic) from mesophyll cells to sieve tube elements in the leaf is called as phloem loading. On the other hand, the transfer of sugars (photosynthetic) from sieve tube elements to the receiver cells of consumption end (i.e., sink organs) is called as phloem unloading. Both are energy requiring processes.

### Phloem Loading:

As a result of photosynthesis, the sugars such as sucrose produced in mesophyll cells move to the sieve tubes of smallest veins of the leaf either directly or through only 2-3 cells depending upon the leaf anatomy. Consequently, the concentration of sugars increases in sieve tubes in comparison to the surrounding mesophyll cells.

The movement of sugars from mesophyll cells to sieve tubes of phloem may occur either through symplast (i.e., cell to cell through plasmodesmata, remaining in the cytoplasm) or the sugars may enter the apoplast (i.e., cell walls outside the protoplasts) at some point en route to phloem sieve tubes.

In the latter case, the sugars are actively loaded from apoplast to sieve tubes by an energy driven transport located in the plasma membrane of these cells. The mechanism of phloem loading in such case has been called as sucrose-$H^+$ symport or cotransport mechanism.

According to this mechanism (Fig. 1 ) protons ($H^+$) are pumped out through the plasma membrane using the energy from ATP and an ATPase carrier enzyme, so that concentration of $H^+$ becomes higher outside (in the apoplast) than inside the cell. Spontaneous tendency toward equilibrium causes protons to diffuse back into the cytoplasm through plasma membrane coupled with transport of sucrose from apoplast to cytoplasm through sucrose -$H^+$ symporter located in the plasma membrane.

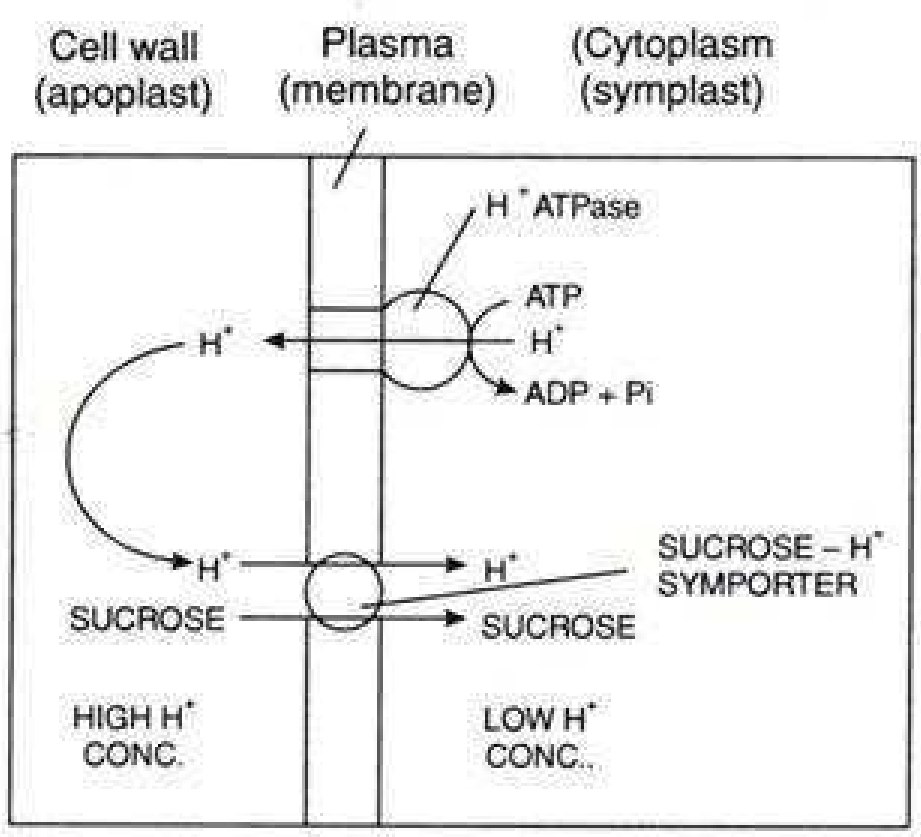


**Fig. 1** Sucrose –H symport or cotransport mechanism.

The mechanism of the transfer of sugars (sucrose) from mesophyll cells to apoplast is however, not known.

Phloem loading is specific and selective for transport sugars. Both symplastic and apoplastic pathways of phloem loading are used in plants but in different species. In some species however, phloem loading may occur through both the pathways in the same sieve tube element or in different sieve tube elements of the same vein or in sieve tubes in veins of different sizes.

Experimental findings have revealed certain patterns in apoplastic and symplastic loading of sugars in phloem (Table 1), which appears to be related with the type of sugar transported to phloem, type of companion cells (ordinary, transfer or intermediary) and number of plasmodesmata (few or abundant ) connecting the sieve tubes (including the companion cells) to surrounding cells in smaller veins.

**Table 1 Patterns in apoplastic and symplastic phloem loading.**

| | Apoplastic loading | Symplastic loading |
|---|---|---|
| Type of sugar transported | Sucrose | Sucrose + other oligosaccharides |
| Type of companion cells in the small veins | Ordinary or transfer cells | Intermediary cells |
| Number of plasmodesmata connecting the sieve tubes (including companion cells) to surrounding cells | Fewer | Abundant |

To some extent, phloem loading is also correlated with the family of plant, its habit (trees, shrubs, vines or herbs) and climate such as temperate, tropical or arid climate.

## Phloem Unloading:

It occurs in the consumption end or sinks organs (such as developing roots, tubers, reproductive structures etc.)

**Sugars move from sieve tubes to receiver cells in the sink involving following steps:**

**(i) Sieve element unloading:**

In this process, sugars (imported from the source) leave sieve elements of sink tissues.

**(ii) Short distance transport:**

The sugars are now transported to cells in sink by a short distance pathway which has also been called as post-sieve element transport.

**(iii) Storage and metabolism:**

As with the phloem loading process, sucrose unloading also occurs through symplast via plasmodesmata or through apoplast at some point en route to sink cells.

Phloem unloading is typically symplastic in growing and respiring sinks such as meristems roots, and young leaves etc. in which sucrose can be rapidly metabolized. (Young leaves act as sink until their photosynthetic machinery is fully developed, at which point they become sources).

Usually, in storage organs such as fruits (grape, orange etc.), roots (sugar beet) and stems (sugarcane), sucrose unloading is known to occur through apoplast. However, according to Oparka (1986), phloem unloading in potato tubers from sieve elements to cortical cells is a symplastic passive process. Because, there are wide varieties of sinks in plants which differ in structure and function, no one scheme of phloem unloading is available.

# II. Source-Sink relationship:

1. **Source sink relationship :** Source sink relationship is a process involved in translocation of photosynthetic products in plants

2. **Definition :** In plants, there is considerable movement of various substances from regions of supply (source) to region of utilization or storage (sink).

3. Sink – Regions of utilization or storage Source- Regions of supply.

4. Inorganic substance like, phosphate ions, etc. Organic substance like, amino acids vitamins growth substances Mainly Sucrose Substances translocate in the phloem.

5. **Important point :** • Phloem translocation always occur from source to sink. It takes place bi-directionally • The speed of phloem sop is relatively very high • The amount of sugar that is trans located also relatively high • The transport taken place according to the hydrostatic pressure.

6. **Mechanism of Phloem Translocation:** Translocation Pathway 3 major steps • Phloem loading • Mass flow • Phloem unloading

7. **Phloem loading :** • Sucrose produce in the mesophyll cells (source) is actively loaded using ATP into the sieve tubes in the phloem of the veinlet of the leaf through transfer cells. This is called Phloem loading.

8. **Mass flow :** • The process of phloem loading increases the solute potential of the sieve tube and decreases the water potential of the sieve tube. Then water enters the sieve tubes by endosmosis from the xylem. So a high hydrostatic pressure is created.

9. • Sucrose solution is then transported to storage organ or growing point (sink) actively or passively by mass flow.

10. **Phloem Unloading :** • At the storage organ (sink) sucrose actively enters to the storage

organ or growing point through transfer cells • This is called phloem unloading

**11.** Source Mesophyll cells Sink (Storage organ) (Growing point)

**12.** Factors determining assimilate / dry matter partitioning

**13.** Vascular connections between source and sink, Distance between source and sink, Sink strength, Supply of energy (strength of source) Amount of assimilates available (Mainly related to leaf area).

**14.** Light intensity, Other climatic condition, Temperature, Mineral nutrition, Moisture stress.

REFERENCES:

1. Fundamentals of Plant Physiology by Dr. V. K. Jain, 2017. (S. Chand).
2. www.biologydiscussion.com

This information, including the figures, are collected from the above references and will be used solely for academic purpose.